Multi-Band Rectangular Microstrip Patch Antenna with Defected Ground Structure and a Metallic Strip

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Abstract— **Microstrip antennas and arrays are small in size any easy to manufacture. The proposed antenna is operated in the S-band and X-band with three resonant frequencies. The antenna has two resonance in the X-band used in Satellite communications Weather mapping and detecting, long-range tracking radar and missile application and the other in the S-band at 4.98GHz frequency WiFi of 13.5Mbps with a bandwidth of 10MHz with the QPSK modulation technique. In this paper the comparison of RMPA with and without DGS and slot is done.**

Keywords- Rectangular Microstrip Patch Antenna (RMPA); Defected Ground Structure (DGS); CST-MW; VSWR; Return loss.

I. INTRODUCTION (HEADING 1)

The low profile antenna is the requirement of modern communication system where the receiver system is miniaturized and light in weight. The size of receiver has small so the mobile devices can handle them easily. Antenna is the essential part of any wireless communication system. The microstrip antenna is easy to handle [1] and size of this type of antenna is small compare to other conventional antenna [2]. These antennas have wide bandwidth and omnidirectional pattern. UWB systems, released by the FCC in 2002 UWB systems between 3.1GHz to 10.6 GHz [3]. This paper presents a rectangular microstrip patch antenna (RMPA) with a defective ground structure (DGS) concept [2][4][5]. Recently to generate the wide bandwidth and frequency band-notch function, modified planar monopoles with inverted U-slot [4][5][6], U-slot [7] and small strip bar [8] are used. The defect is constructed on the both side of feed symmetrically for enhancing the impedance bandwidth and return loss [3]. A small thick metallic strip is given opposite side of the feed on the ground plane. The antenna is simulated in the CST-MW software [9] with frequency range of 2GHz to 14 GHz for wideband applications. By placing the symmetrical rectangular slot on the both side of feed the thickness W_s of strip varying and the result is obtain and tabulated. So the antenna is used in Weather, traffic control, tracking, Satellite communications [10], missile guidance, Weather mapping and detecting[11], long-range Tracking in the X-band in the higher order resonant frequency at 8.0GHz and 10.3GHz. The lower band is obtained in the S-band at the resonant frequency 4.98GHz it is used in the Wi-Fi of 13.5Mbps with a bandwidth of 10MHz with the QPSK modulation technique [12].

II. ANTENNA DESIGN

The antenna is design and analysis by using the transmission line model [1]. The patch is 13.25mm ×10.02mm and the width of feed line is 2.7458mm for impedance matching at the given dielectric constant 4.3 and height of substrate 1.6mm with the loss tangent 0.02. The both slots are same in parameter 6mm×2mm placed symmetrically as shown in the fig.1 the dimensions of the metallic case is 22mm× 6mm where the slots are placed. The metallic strip of thickness *W*s is given at opposite side of feed as shown fig.1.The dimension of ground plane is 22mm×25mm. As the width of metallic strip is change the separation between the slot's case and strip is varied hence the current distribution on the antenna is varied [2].

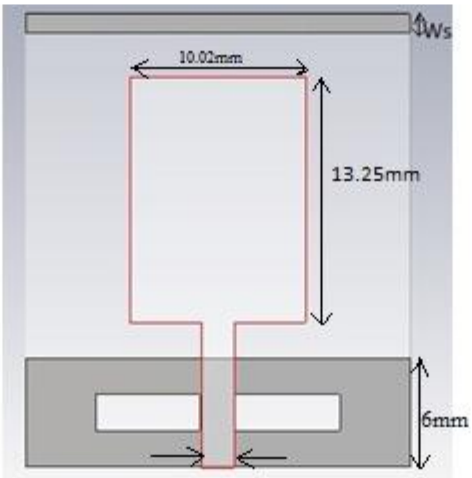

Figure 1. Geometrical view of proposed RMPA

III. RESULTS

The simulated results are obtained on the CST-MW software [9]. The strip width Ws is varying from 0.5mm to 4.0mm and results are obtained. The RMPA with DGS and slots increases the bandwidth, radiation and antenna efficiency etc. In the three bands the directivity of the antenna, VSWR, S-parameter and impedance bandwidth are also analyzed and summarized.

First the RMPA without any strip is simulated in the CST-MW software the resonant is occur at the frequency of 10.203GHz in the X-band the impedance bandwidth is find 340.63MHz. The radiation pattern is also draw then radiation characteristics such as efficiency find in the order of -3dB, and directivity of the order of 7dBi is obtained. The result is tabulated below.

TABLE I. SIMULATED RESULTS FOR RMPA WITHOUT THE STRIP

S.No.	Central resonant frequency	f_1=10.203GHz
1	Return loss in dB	-19.620dB
2	VSWR	1.2330
3	Impedance bandwidth	340.63MHz
4	Radiation efficiency in dB	-3.327dB
5	Total efficiency in dB	-3.375dB
6	Directivity in dBi	6.80dBi

The ground plane of the RMPA is defected symmetrically both side on feed with a slot of 6mm×2mm and a strip is located in the opposite extreme edge on the ground plane then multiple bands are obtained. This done due to the current distribution in the nonmetallic part is changed, and it varied with strip width W_s. If the strip width W_s is varied then the variation in all the parameter is obtained. Hence it performs the impedance matching with the help of strip. The related simulated figures are shown in the end of this discussion. The values of a simple RMPA in X-band designed and simulated these result tabulated in the Tab.2. The other two table is presents the antenna performance with two slots as DGS and a thin strip on the ground plane.

The value is measured from the Fig2-Fig7 and tabulated. The Fig.2 showed S-parameter vs. frequency graph. Fig.3 has given the VSWR values in the three resonant frequency bands and so on.

Now the antenna with the strip width Ws=0.5mm, simulated and the three band with wide bandwidth is achieve the maximum bandwidth has 1.2802GHz at 10.302GHz. The bandwidth at all the bands is achieved of the order of 10-12%. The radiation efficiency is measured is 94.06% to 64.41% at *f1, f2, f3* frequency respectively.

TABLE II. SIMULATED RESULTS FOR TWO SLOTS AND *WS*=0.5MM

S.No.	Parameter	f_1=4.996 GHz	f_2=8.034 GHz	f_3=10.302GHz
1	Return loss in dB	-13.905	-30.728	-12.376
2	VSWR	1.5053	1.0598	1.633
3	Impedance Band width	874.93 MHz	770.44 MHz	1.2802 GHz
4	Radiation efficiency	-0.267dB	-0.820dB	-1.043dB
5	Total efficiency	-0.447dB	-0.824dB	-1.302dB
6	Directivity	2.694dBi	4.283dBi	4.793dBi

Now the same antenna with the slot width Ws=1.0mm, simulated and the three band with wide bandwidth is achieve the maximum bandwidth has 1.2537GHz. The bandwidth at all the bands is achieved of the order of 10%. The radiation efficiency is measured is -0.2659dB,-0.8685dB,-0.9830dB at *f1, f2, f3* frequency respectively.

TABLE III. SIMULATED RESULTS FOR TWO SLOTS AND WS=1.0MM

S.No.	Parameter	f_1=4.982 GHz	f_2=8.006 GHz	f_3=10.33 GHz
1	Return loss in	-13.98dB	-44.65dB	-13.31dB
2	VSWR	1.4995	1.0117	1.5510
3	Impedance Band width	857.33 MHz	730.25 MHz	1.2537 GHz
4	Radiation efficiency(dB)	-0.2659	-0.8685	-0.9830
5	Total efficiency (dB)	-0.4429	-0.8686	-1.191
6	Directivity	2.658dBi	4.284dBi	4.736dBi

The above result found by simulated result on the electromagnetic solver gives the graph between frequency and various characteristics such as return loss, VSWR, smith chart for impedance matching, crossover and finding the stability. The radiation pattern plot showed the directivity, gain, radiation efficiency, antenna efficiency etc. The impedance bandwidth is measured in the S-parameter at -10dB line or at VSWR at the numeric value 2.

IV. CONCLUSION

The circularly polarized wide band antenna is simulated in the frequency band of 2GHz to 14GHz and gives the three resonant bands having the directivity of the order of 6-8dBi with S11 of the order of ≤-10dB. All three bands give a wide band-width at the center frequencies in the center frequency near 10.3GHz the impedance bandwidth about 1.25GHz is achieved for the use in Radar[10] and Satellite communication[11]. The another center frequency in the X-band nearly about 8.0GHz at this frequency the impedance bandwidth nearly 750MHz is achieved for the use of long-range tracking, weather detection, air traffic control and missile guidance[11] etc. The lowest center frequency is laid in S-band near about 4.98GHz this put a milestone in this research this frequency band is assign by the FCC for WiFi of the user speed of 13.5Mbps with a bandwidth of 10MHz with the QPSK / 16APSK / 32APSK / 64QAM / 128QAM modulation techniques[12].

REFERENCES

[1] Constantine A Balanis.: *Antenna Theory, Analysis and Design.* 2nd Edition, John Wiley, New York, 1998.

[2] C.A. Balanis. : *Advanced Engineering Electromagnetics*, John Wiley & sons, New york, 1989.

[3] FCC, First Report and Order on Ultra-Wideband Technology, 2002.

[4] Hemant Kumar Gupta, P.K. Singhal, Pavan Kumar Sharma and Veerendra Singh Jadaun.: *Slotted Circular Microstrip Patch Antenna Designs for multiband application in wireless communication* Science Publishing Cooperation Journal name International Journal of Engineering and Technology (IJET) in Vol.1 No.3 2012 P.158-167 UAE.

[5] Pavan Kumar Sharma, Hemant Kumar Gupta, Veerendra Singh Jadaun, Ritesh Kumar Tambulkar.: *Sierspinski Carpet Microstrip Patch Antenna for Wireless Communication in ISM band at 2.45GHz*. Proceeding of the 1st International Conference E-Manthan-2012 July 2012 P.317-319.

[6] K. Chung, J. Kim, and J. Choi.: *Wideband microstrip-fed monopole antenna having frequency band-notch function, IEEE Microw. Wireless Compon. Lett.*, vol. 15, no. 11, pp. 766–768, Nov. 2005.

[7] Y. J. Cho, K. H. Kim, D. H. Choi, S. S. Lee, and S.-O. Park.: *A miniature UWB planar monopole antenna with 5-GHz band-rejection*

filter and the time-domain characteristics, IEEE Trans. Antennas Propag., vol. 54, no. 5, May 2006.

[8] K. Chung, S. Hong, and J. Choi, :*Ultrawide-band printed monopole antenna with band-notch filters, IET Microw. Antennas Propag.*, vol.1, no.2,p. 518–522Apr.2007.

[9] http://www.cst.com/content/products/mws/overview.aspx © 2012 CST Computer Simulation Technology AG.

[10] Ralph Pokuls; Jaroslaw Uher; D. M. Pozar.: *Dual-Frequency and Dual-Polarization Microstrip Antennas for SAR Applications.*IEEE transactions on antennas and propagation, vol.46, no. 9, September 1998 p.1289-1296.

[11] F. Ferrero, C. Luxey, G. Jacquemod, and R. Staraj.: *Dual-Band Circularly Polarized Microstrip Antenna for Satellite Applications* IEEE antennas and wireless propagation letters, vol. 4, 2005 p.13-15.

[12] http://www.saftehnika.com According to ETSI channel plan CFIP series Microwave radio unit © SAF Tehnika JSC Ver. 1.3 2010

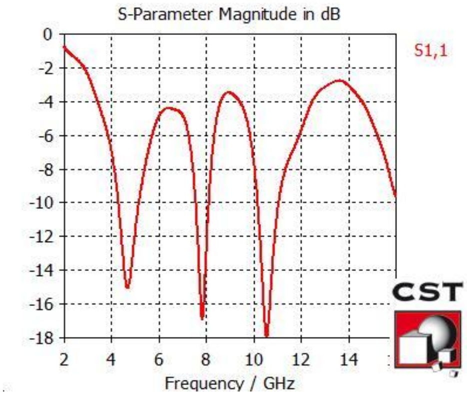

Figure 2. S-parameter of proposed antenna

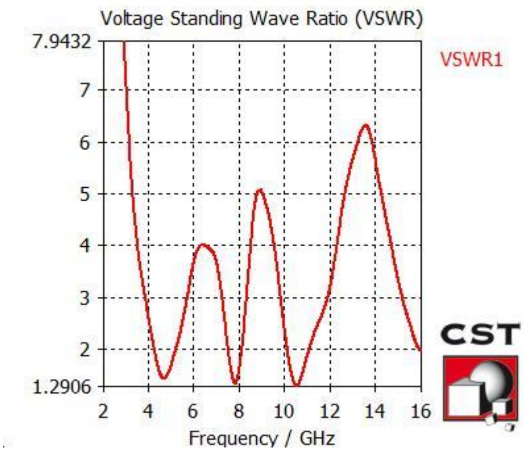

Figure 3. VSWR of proposed antenna

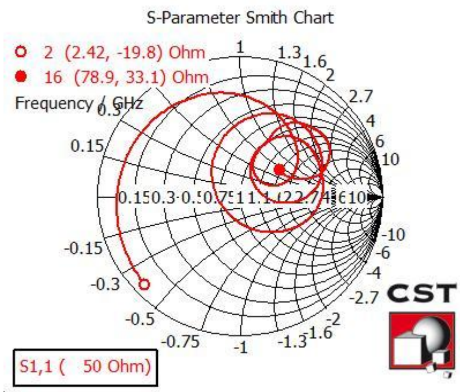

Figure 4. Smith chart of proposed antenna

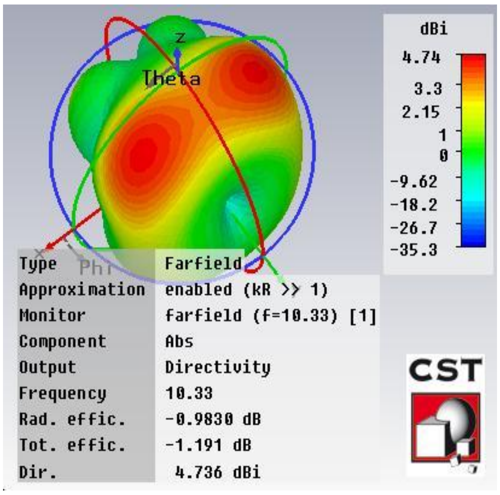

Figure 5. Radiation view for 10.33GHz

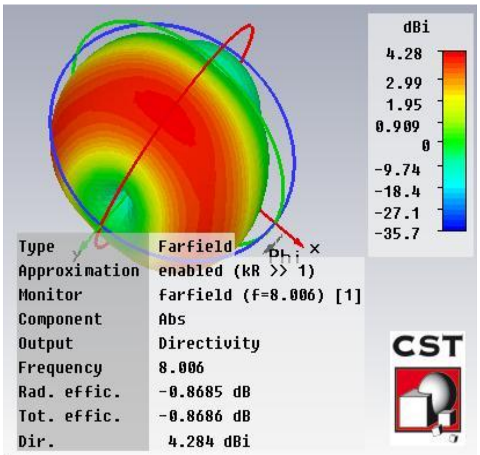

Figure 6. Radiation view for 8.006GHz

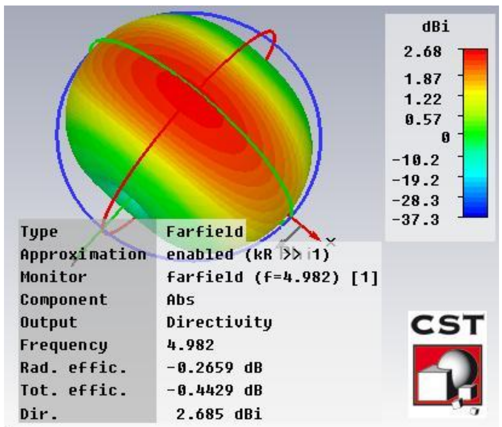

Figure 7. Radiation view for 4.982GHz